1.5. METEOROLOGICAL MEASUREMENTS

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1.5.1. METEOROLOGY OPERATIONS

Introduction

The climatology of surface meteorological observations at the four CMDL observatories is based on hourly average measurements of the prevailing wind direction and speed, barometric pressure, ambient and dewpoint temperatures, and precipitation amounts. The meteorological sensors in use were selected for their high accuracy as well as their ability to withstand the extreme conditions of both the tropics and polar regions. Data is recorded as 1-min averages so that the variability within the hourly averages can be determined. To the extent that is possible, World Meteorological Organization (WMO) siting standards [*WMO*, 1969] are followed. Thermometers are also positioned at the top of the sampling towers at the Barrow Observatory (BRW), Mauna Loa Observatory (MLO), and South Pole Observatory (SPO) to measure the temperature gradient and to determine the stability of the surface boundary layer.

Peterson and Rosson [1994] give a detailed description of the PC-based data acquisition system. Table 1.5 describes the CMDL instrument deployment as of December 31, 2001.

Data Management

The meteorological data acquisition system gathers data from sensors that operate continuously at each of the four CMDL observatories. Data are transferred from the observatories to Boulder daily via the Internet, except for the Samoa Observatory (SMO), whose data are transferred to Boulder weekly. Preliminary hourly averages of prevailing wind direction and speed, barometric pressure, ambient and dewpoint temperatures, and precipitation amounts are sent to the stations daily, except for SMO, which are sent weekly.

A comparison of the number of data points recorded against that expected for the year was used to monitor each system's performance. Table 1.6 shows the performance for each station in 2000 and 2001. On average, the meteorological data acquisition system combined for the four observatories operated 92.65% and 91.92% of the time for 2000 and 2001, respectively. Because of the remoteness of the observatories, power outages are common and are the main reason for data loss. Hardware failure, system restarts, and system maintenance are the other reasons. At BRW, during the winter, rime ice and snow occasionally build up on the sensors and have to be removed manually.

1.5.2. STATION CLIMATOLOGIES

The 25-yr station climatologies are an important record for the interpretation of measured values of aerosols, trace gases, atmospheric turbidity, and solar radiation, and the long-term changes in the records themselves, and they serve to outline periods of local contamination.

Barrow

In Figure 1.1, wind roses of hourly average prevailing wind direction and wind speed (WS) at BRW are presented in 16 direction classes and 3 speed classes. Winds from the "clean air" sector, north-northeast to southeast, occurred 62.6% of the time in 2000 and 64.0% in 2001 compared with 61.4% for the 23-yr period from 1977 through 1999 (Figure 1.2). Wind speeds in excess of 10 m s^{-1} in 2000 (11.4%) were more frequent than for the 23-yr climatology (10.8%), whereas in 2001 (7.1%) they were less frequent than in the 23-yr climatology. The average wind speeds of 5.8 m s^{-1} in 2000 and 5.5 m s^{-1} in 2001 (Table 1.7) were slightly below the long-term average (6.0 m s^{-1}).

The average air temperatures of –11.5°C in 2000 and –11.7°C in 2001 (Table 1.7) were both warmer than the climatological average of –12.2°C. The barometric pressure in 2000 was 0.5 hPa above the 23-yr average of 1014.1 hPa, and the average for 2001 was 0.4 hPa below the

TABLE 1.5. CMDL Meteorological Sensor Deployment December 31, 2001

	BRW		MLO		SMO		SPO	
Sensor	Serial No.	Elevation* (m)	Serial No.	Elevation* (m)	Serial No.	Elevation* (m)	Serial No.	Elevation* (m)
Primary anemometer†	14584	10.5	23186	10.2	15945	22.9	14583	10.3
Secondary anemometer†			15946	38.2				
Pressure transducer‡	374199	9.5	374198	3398.4	374200	78.5	358960	2841.0
Mercurial barometer	641	9.5	278	3398.4	961	78.5	1215A	2841.0
Air temperature A§		2.4		2.0		18.9		1.6
Air temperature B§¶		15.7		37.4		18.9		22.0
Air temperature C**		2.9		2.0		18.9		2.0
Dewpoint temperature	G0001	2.9	G0004	2.0	G0008	18.9	G0007	2.0
Rain gauge		~4		0.8		~4		

*Heights are in meters above surface, except for the pressure transducer and mercurial barometer, which are with respect to mean sea level (MSL).

†Propeller anemometer, model no. 05103, R. M. Young Company, Traverse City, Michigan.

‡Pressure transducer, model no. 270, Setra Systems, Acton, Massachusetts.

§Platinum resistance probe, Logan 4150 Series, Logan Enterprises, Liberty, Ohio.

¶Thermometer, positioned at the top of the local sampling tower to facilitate an estimation of boundary layer stability, except at SMO where both sensors were at the same height.

**Hygrothermometer, model no. 1088-400, Technical Services Laboratory, Fort Walton Beach, Florida.

TABLE 1.6. CMDL Meteorological Operations Summary

Station	Expected Number of Data Points	Data Capture (%)	Number of Missing Data Points
		2000	
BRW	4,216,320	98.36	68,959
MLO	6,851,520	91.55	579,028
SMO	4,216,320	83.95	676,523
SPO	4,216,320	96.74	137,395
Average		92.65	
		2001	
BRW	4,204,800	97.34	111,693
MLO	6,832,800	86.82	900,727
SMO	4,204,800	93.43	276,424
SPO	4,204,800	90.10	416,135
Average		91.92	

climatological average. May and August 2000 recorded new record-high barometric pressure readings for the respective months. The summertime precipitation amounts for 2000 (63 mm) and 2001 (57 mm) were above the long-term average of 39 mm.

Mauna Loa

The climatology of MLO is best understood when it is considered in two distinctive wind regimes, the night (downslope) period of 1800-0559 Hawaiian Standard Time (HST) and the day (upslope) period of 0600-1759 HST. The 23-yr (1977-1999) night and day wind charts illustrate the two distinct wind regimes (Figure 1.3).

For the night regime at MLO, the 23-yr wind rose (Figure 1.3) shows that 89.9% of all winds observed had a southerly component. The percentage occurrence of southerly winds was 89.4% in 2000 (Figure 1.4) and 90.1% in 2001 (Figure 1.5). Pressure-gradient-controlled winds (WS ≥ 10 m s^{-1}) from predominantly westerly and southeasterly directions, occurred 5.0% of the time in 2000 and 4.7% in 2001, both of which were below the 23-yr average of 6.9%. The annual average wind speeds for 2000 and 2001 were both below the long-term average (Tables 1.8 and 1.9). The upslope, or northerly component, winds (north-northwest through east-northeast) that occurred 4.8% of the time in 2000 and 3.9% in 2001 are the result of the daytime upslope flow extending into the early evening hours.

For the day regime at MLO, the 2000 and 2001 wind roses (Figures 1.4 and 1.5) indicate that winds from the west-northwest through east-southeast occurred 72.6% of the time in 2000 and 71.5% of the time 2001, compared with 60.2% for the 23-yr climatology (Figure 1.3). Pressure-gradient-controlled winds (WS ≥ 10 m s^{-1}) occurred 3.6% of the time in 2000 and 2001, both of which were lower than the climatological average of 6.9%. In 2000 and 2001 the pressure gradient winds, which are usually associated with storms, followed the expected pattern of fewer occurrences during the day regime. The day wind chart is more uniformly distributed in the light-wind classes than the night wind chart. This is due to the occurrence of variable wind directions during the transition periods at dawn and dusk, most of which are included in the day regime.

The average ambient temperature for 2000 (Table 1.8), combining both day and night regimes, was 7.1°C, which equals the long-term average of 7.1°C, whereas the 6.7°C in 2001 (Table 1.9) was below the long-term average. The average barometric pressure for 2000 (680.1 hPa) was below the climatological average of 680.5 hPa, whereas for 2001 (680.4 hPa) it was near the climatological average. June 2000 tied the record minimum pressure value for the month, and January 2001 set a new maximum barometric pressure record for the month. The total precipitation amount in 2000 (212 mm) was considerably below the long-term average of 352 mm, whereas in 2001 (359 mm) it was slightly above the long-term average.

Samoa

A comparison of SMO's 2000 and 2001 wind roses (Figure 1.6) to the wind rose of the 23-yr period (Figure 1.7) shows a considerably higher percentage of "clean air" sector winds (north-northwest through southeast) in 2000 (77.6%) and 2001 (73.4%) than the long-term average of 58.5%. The occurrence of winds in the 10 m s^{-1} or greater class was 9.8% in 2000 and 14.0% in 2001, whereas the expected occurrence based on the climatological average is 5.0%. The annual average wind speeds for 2000 (5.9 m s^{-1}) and 2001 (6.0 m s^{-1}) (Table 1.10) were both above the long-term average of 5.0 m s^{-1}. No wind data are available for January-March 2000 because of instrument problems.

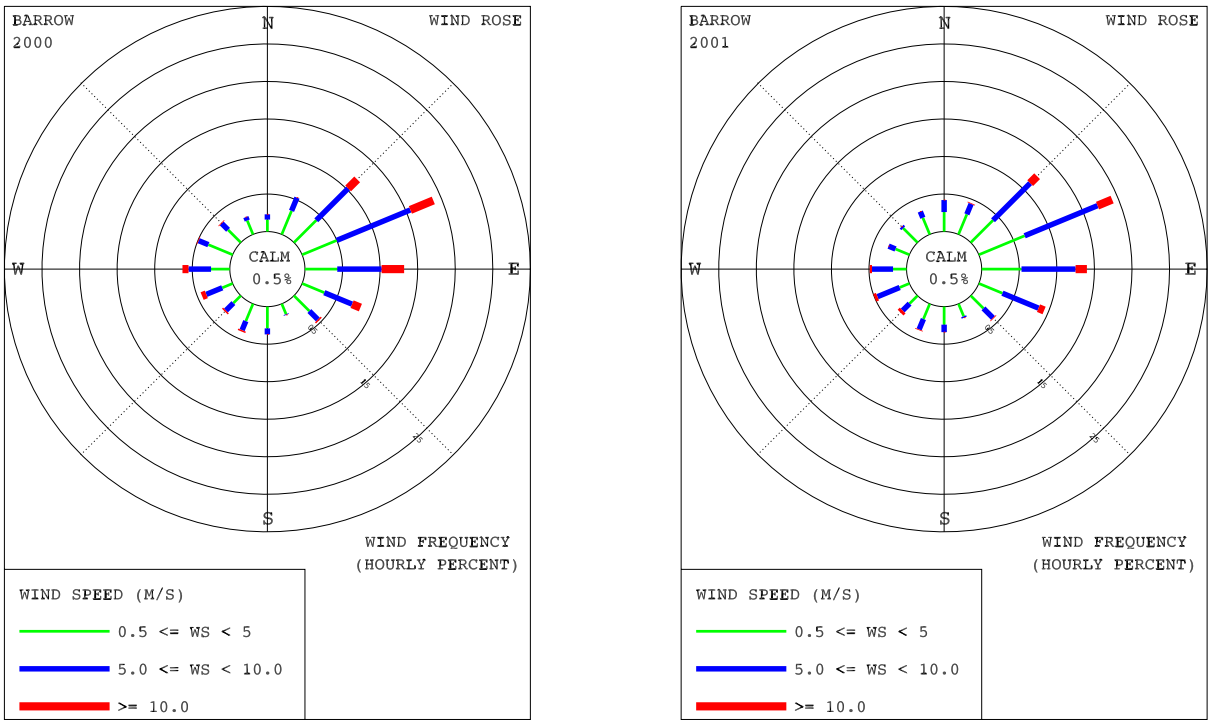


Fig. 1.1. Wind roses of the surface winds at BRW for 2000 (left) and 2001 (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for 16 direction classes and 3 wind speed (WS) classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.

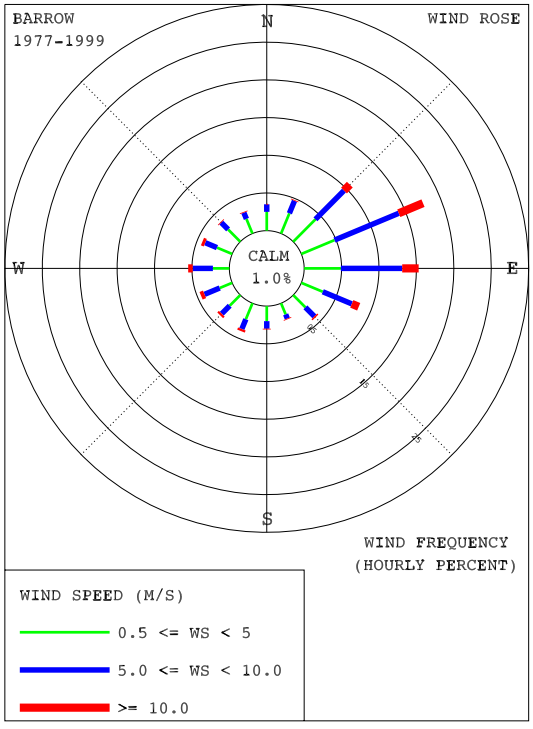


Fig. 1.2. Wind rose of surface winds at BRW for 1977-1999. The distributions of prevailing wind direction and speed are given in units of percent occurrence for the 23-yr period for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graph.

TABLE 1.7. BRW 2000 and 2001 Monthly Climate Summary

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							2000						
Prevailing wind direction	W	ENE	ENE	E	ESE	ESE	ENE	E	ESE	NE	ENE	ENE	ENE
Average wind speed (m s^{-1})	5.1	5.1	7.4	5.2	4.0	4.2	5.3	6.3	5.1	6.1	7.4	7.9	5.8
Maximum wind speed* (m s^{-1})	14.7	11.8	14.3	14.5	9.0	13.5	15.2	21.9	13.2	14.5	20.6	18.3	21.9
Direction of max. wind* (deg.)	270	54	82	55	113	230	238	251	346	77	74	89	251
Average station pressure (hPa)	1011.9	1014.6	1017.7	1022.2	1017.3	1011.0	1010.1	1013.6	1008.6	1008.9	1014.9	1024.3	1014.6
Maximum pressure* (hPa)	1036.4	1032.1	1037.4	1037.6	1041.1	1029.6	1027.9	1035.8	1025.2	1022.3	1034.4	1035.7	1041.1
Minimum pressure* (hPa)	979.6	997.6	1001.6	1004.8	1003.7	995.0	995.6	996.3	994.4	992.3	996.6	1009.2	979.6
Average air temperature (°C)	-25.0	-26.6	-24.5	-17.9	-9.5	1.5	2.9	3.2	0.3	-7.2	-16.3	-19.8	-11.5
Maximum air temperature* (°C)	-11.9	-9.3	-15.0	-4.6	-0.4	16.2	19.3	15.3	12.7	0.3	-6.1	-10.0	19.3
Minimum air temperature* (°C)	-39.2	-41.1	-35.7	-29.5	-22.5	-5.1	-2.2	-1.6	-7.1	-18.3	-28.5	-31.4	-41.1
Average dewpoint temperature (°C)	-28.1	-29.7	-27.8	-20.5	-11.4	-0.1	1.6	0.3	-1.8	-9.1	-18.6	-22.4	-14.7
Maximum dewpoint temperature* (°C)	-13.4	-10.6	-18.4	-5.5	-1.7	10.0	12.6	6.9	7.9	-0.1	-7.6	-11.4	12.6
Minimum dewpoint temperature* (°C)	-43.3	-45.9	-40.0	-33.0	-24.8	-7.6	-2.6	-3.0	-9.8	-20.1	-31.9	-35.3	-45.9
Precipitation (mm)	0	0	0	0	2	11	31	14	5	0	0	0	63
							2001						
Prevailing wind direction	ENE	ENE	ENE	ENE	E	ESE	ENE	E	E	NE	ENE	ENE	ENE
Average wind speed (m s^{-1})	7.7	6.4	6.3	5.6	4.0	5.0	5.2	5.7	5.1	5.4	5.7	4.4	5.5
Maximum wind speed* (m s^{-1})	21.3	16.2	13.2	12.6	10.1	11.9	10.7	12.4	11.7	11.8	13.5	12.1	21.3
Direction of max. wind* (deg.)	61	278	48	67	142	235	237	256	87	42	83	252	61
Average station pressure (hPa)	1009.7	1014.7	1023.4	1016.0	1017.3	1016.7	1011.5	1007.7	1006.7	1016.9	1013.1	1011.0	1013.7
Maximum pressure* (hPa)	1029.8	1043.9	1046.9	1036.9	1031.2	1029.7	1024.5	1024.1	1017.8	1033.4	1032.0	1039.9	1046.9
Minimum pressure* (hPa)	981.6	988.8	997.0	997.6	1006.6	1001.6	995.3	992.0	991.7	994.0	990.2	990.6	981.6
Average air temperature (°C)	-23.3	-18.9	-26.5	-16.7	-10.9	0.8	2.3	1.7	0.1	-11.9	-16.4	-21.9	-11.7
Maximum air temperature* (°C)	-10.2	-5.1	-15.8	-6.8	1.2	11.1	19.9	11.7	13.0	-2.4	-5.8	-5.3	19.9
Minimum air temperature* (°C)	-33.2	-33.5	-35.8	-32.4	-24.3	-4.1	-2.4	-2.0	-7.8	-24.5	-26.9	-31.6	-35.8
Average dewpoint temperature (°C)	-25.4	-20.9	-29.3	-19.1	-12.8	-0.6	0.3	-0.5	-1.2	-13.9	-18.9	-24.8	-14.2
Maximum dewpoint temperature* (°C)	-12.0	-6.2	-18.0	-8.8	-0.5	5.9	12.8	7.0	6.0	-3.5	-7.0	-7.1	12.8
Minimum dewpoint temperature* (°C)	-35.7	-36.3	-39.3	-35.2	-27.3	-5.7	-3.9	-4.0	-10.8	-27.3	-30.5	-36.0	-39.3
Precipitation (mm)	0	0	0	0	0	2	30	20	5	0	0	0	57

Instrument heights: wind, 10.5 m; pressure, 9.5 m (MSL); air temperature, 2.9 m; dewpoint temperature, 2.9 m. Wind and temperature instruments are on a tower 25 m northeast of the main building.

*Maximum and minimum values are hourly averages.

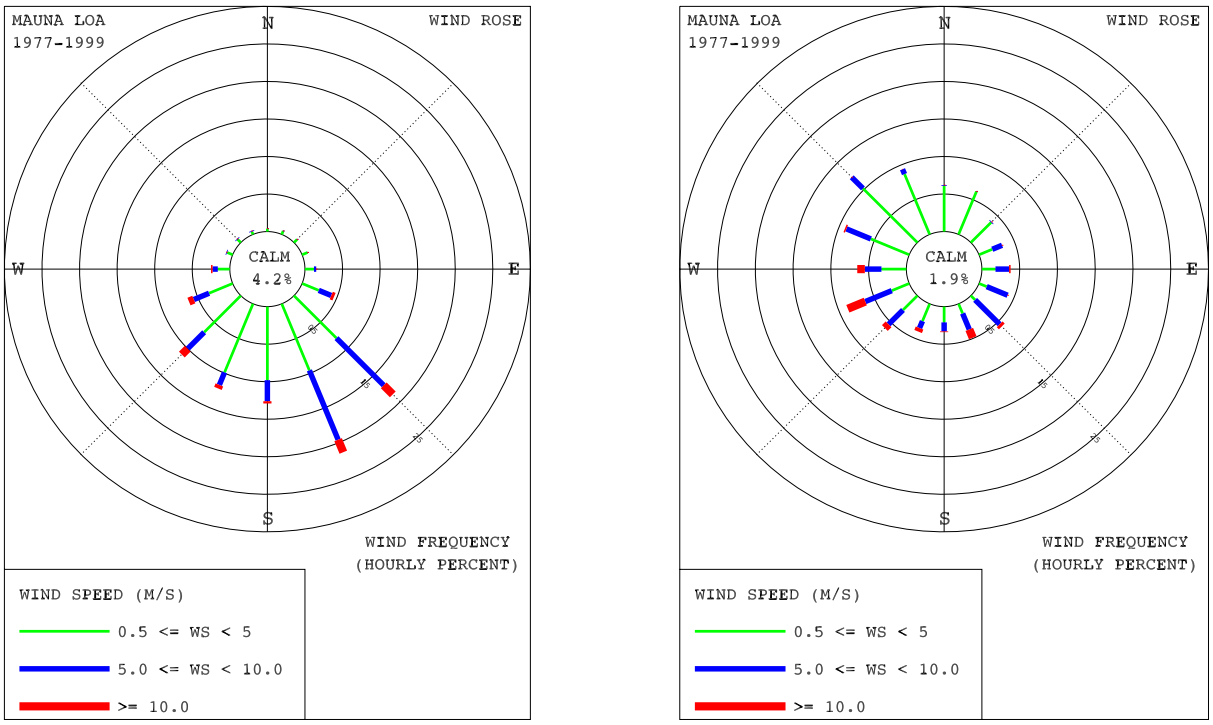


Fig. 1.3. Wind roses of the surface winds at MLO for 1997-1999 night (left) and day (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for the 23-yr period for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.

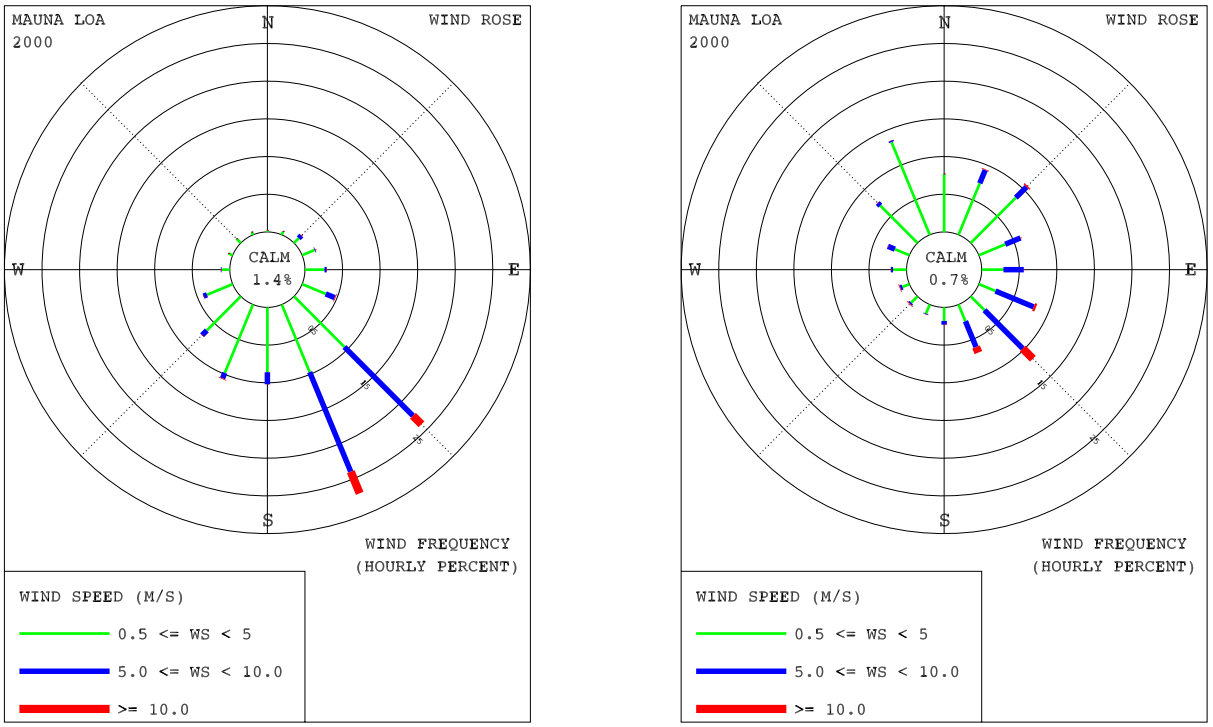
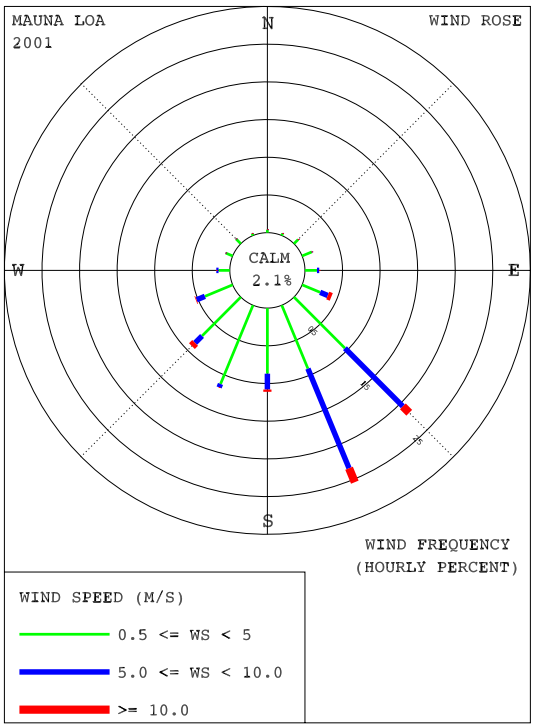


Fig. 1.4. Wind roses of the surface winds at MLO for 2000 night (left) and day (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.



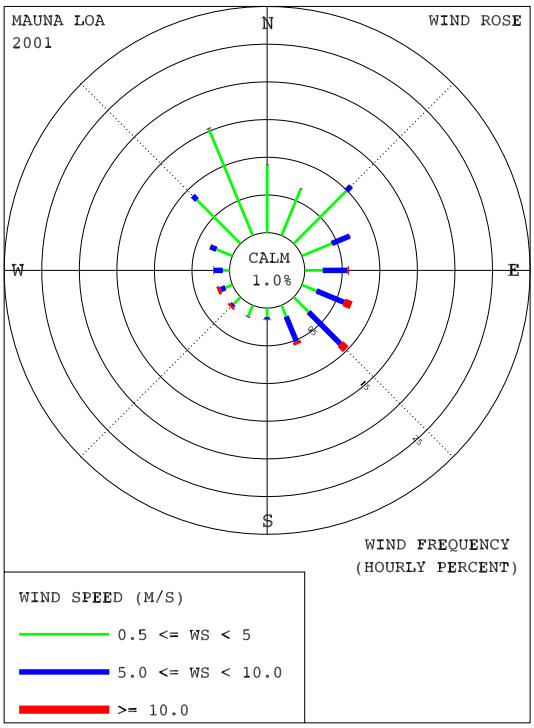
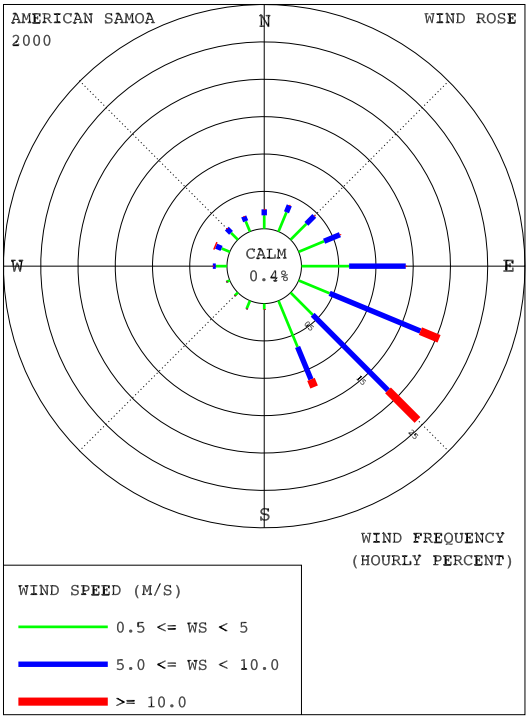


Fig. 1.5. Wind roses of the surface winds at MLO for 2001 night (left) and day (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.



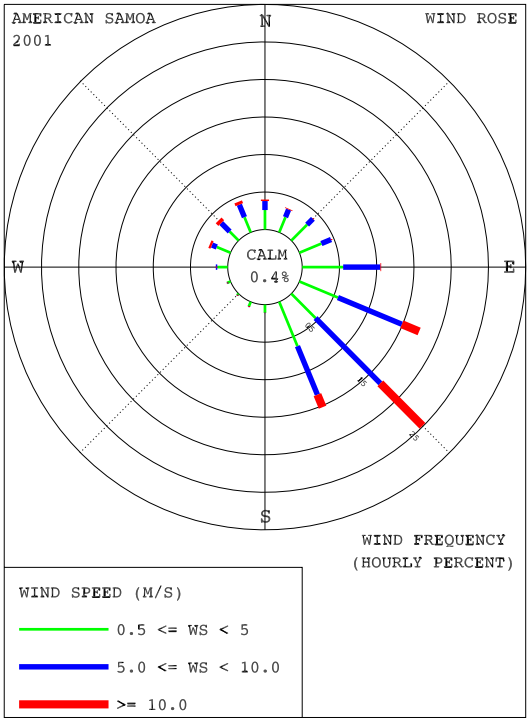


Fig. 1.6. Wind roses of the surface winds at SMO for 2000 (left) and 2001 (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.

TABLE 1.8. MLO 2000 Monthly Climate Summary

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							Night						
Prevailing wind direction	SE	SSE	SE	SSE	SSE	E	SSE	SE	SE	SE	SSE	SSE	SSE
Average wind speed (m s^{-1})	4.4	5.6	6.2	5.5	4.5	4.0	3.9	4.2	3.0	4.2	4.4	4.3	4.5
Maximum wind speed* (m s^{-1})	13.8	16.8	15.2	13.0	12.1	13.6	12.5	9.2	9.1	12.6	11.1	13.6	16.8
Direction of max. wind* (deg.)	154	154	155	158	170	157	155	140	152	152	239	153	154
Average station pressure (hPa)	678.3	680.9	679.7	679.9	680.8	680.1	680.7	680.4	680.3	680.1	679.7	679.9	680.1
Maximum pressure* (hPa)	683.0	683.9	682.5	683.2	684.5	683.1	683.5	682.3	683.2	682.6	681.8	683.0	684.5
Minimum pressure* (hPa)	673.7	678.5	676.2	675.3	677.6	676.7	678.0	677.5	677.1	677.8	677.0	676.5	673.7
Average air temperature (°C)	2.1	4.3	3.3	4.9	6.9	6.9	6.4	6.7	6.7	5.3	3.3	4.5	5.1
Maximum air temperature* (°C)	7.9	10.2	9.9	11.0	12.1	13.7	13.1	12.3	11.2	10.9	7.7	9.3	13.7
Minimum air temperature* (°C)	-2.6	-0.5	-1.8	-2.3	2.7	0.6	3.2	2.5	1.9	1.7	-1.0	-0.1	-2.6
Average dewpoint temperature (°C)	-12.8	-15.3	-16.9	-19.3	-13.5	-16.1	-7.0	-11.4	-6.7	-8.6	-8.6	-16.9	-12.8
Maximum dewpoint temperature* (°C)	3.1	3.8	1.9	2.7	3.1	6.2	6.9	7.8	7.7	7.1	5.5	6.5	7.8
Minimum dewpoint temperature* (°C)	-30.8	-33.8	-30.5	-35.9	-29.3	-30.8	-19.4	-31.5	-27.0	-28.1	-25.8	-30.5	-35.9
Precipitation (mm)	1	0	0	0	0	0	0	2	2	0	22	0	27
							Day						
Prevailing wind direction	NNW	SE	SE	SE	NNE	NNE	NNW	NNW	NE	NNW	SE	NNW	NNW
Average wind speed (m s^{-1})	4.3	5.0	6.1	5.2	4.9	4.1	4.1	3.4	2.6	3.5	3.8	3.3	4.2
Maximum wind speed* (m s^{-1})	13.3	13.0	14.8	11.8	11.6	10.5	11.4	8.6	7.9	12.2	11.7	10.0	14.8
Direction of max. wind* (deg.)	152	141	143	148	186	36	148	131	156	141	245	141	143
Average station pressure (hPa)	678.2	680.9	679.7	680.0	680.8	680.2	680.8	680.6	680.3	680.0	679.6	679.8	680.1
Maximum pressure* (hPa)	682.9	683.6	683.2	682.6	684.0	682.6	683.4	682.7	682.9	682.4	681.9	683.3	684.0
Minimum pressure* (hPa)	673.4	678.4	676.3	675.4	678.2	677.5	678.4	677.6	677.3	677.8	676.7	677.3	673.4
Average air temperature (°C)	5.2	8.6	7.5	9.3	11.5	10.9	10.7	10.2	10.7	9.0	7.0	8.3	9.1
Maximum air temperature* (°C)	11.6	15.0	14.3	16.5	16.5	18.2	16.0	16.5	16.2	15.4	12.5	14.0	18.2
Minimum air temperature* (°C)	-2.3	0.2	-1.4	-1.4	4.8	2.5	4.2	2.9	3.3	1.9	-1.2	-0.4	-2.3
Average dewpoint temperature (°C)	-8.2	-12.3	-11.9	-13.0	-8.0	-6.0	-1.0	-2.4	-0.7	-3.7	-6.1	-9.8	-7.0
Maximum dewpoint temperature* (°C)	8.0	5.3	5.6	5.3	5.4	7.2	9.5	8.4	9.6	8.1	7.4	9.4	9.6
Minimum dewpoint temperature* (°C)	-31.2	-29.7	-29.4	-34.2	-27.8	-28.9	-19.1	-31.4	-27.2	-26.8	-25.5	-30.2	-34.2
Precipitation (mm)	4	7	0	0	0	2	0	28	30	47	67	0	185

Instrument heights: wind, 10.2 m; pressure, 3398.4 m (MSL); air temperature, 2.0 m; dewpoint temperature, 2.0 m. Wind and temperature instruments are on a tower 15 m southwest of the main building.

*Maximum and minimum values are hourly averages.

TABLE 1.9. MLO 2001 Monthly Climate Summary

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							Night						
Prevailing wind direction	SSE	SE	SE	SSE	SSE	S	SE	SSE	SE	SE	SSE	SSE	SSE
Average wind speed (m s^{-1})	5.5	4.7	4.2	3.1	3.0	2.9	3.2	4.4	3.6	4.1	4.4	8.4	4.3
Maximum wind speed* (m s^{-1})	11.9	11.4	10.3	10.2	8.6	8.1	11.3	10.7	11.4	12.0	15.7	16.7	16.7
Direction of max. wind* (deg.)	157	158	158	159	155	164	165	117	156	154	173	151	151
Average station pressure (hPa)	680.7	678.2	679.3	680.2	680.5	680.4	680.9	681.5	681.0	680.4	681.3	679.5	680.3
Maximum pressure* (hPa)	684.3	681.6	684.4	682.8	683.1	683.2	682.8	684.7	683.6	683.9	684.1	682.6	684.7
Minimum pressure* (hPa)	676.7	671.8	675.1	676.5	677.5	677.4	678.5	679.2	677.9	677.2	675.2	675.3	671.8
Average air temperature (°C)	4.5	2.6	2.9	3.8	4.6	5.2	6.6	6.6	6.1	5.4	5.8	4.2	4.8
Maximum air temperature* (°C)	10.7	8.4	11.1	8.9	11.3	11.5	12.4	12.2	11.1	9.8	11.1	8.3	12.4
Minimum air temperature* (°C)	-0.5	-0.9	-1.7	-0.8	-0.3	0.4	1.9	1.5	1.3	1.0	0.9	-1.0	-1.7
Average dewpoint temperature (°C)	-18.2	-10.3	-19.7	-14.5	-11.6	-8.4	-10.9	-8.7	-9.5	-9.8	-11.2	-15.0	-12.6
Maximum dewpoint temperature*(°C)	4.9	1.7	2.9	4.7	4.4	6.1	5.9	8.0	7.2	7.0	5.5	4.9	8.0
Minimum dewpoint temperature* (°C)	-37.0	-33.7	-35.7	-30.2	-27.9	-29.4	-26.9	-24.5	-26.3	-27.5	-30.1	-31.6	-37.0
Precipitation (mm)	0	17	0	0	0	0	0	0	6	8	69	67	167
							Day						
Prevailing wind direction	SE	NNW	NE	NNW	NE	NNW	NNW	NE	NNW	NW	NNW	SE	NNW
Average wind speed (m s^{-1})	4.7	4.1	3.8	3.1	2.9	3.0	3.3	4.2	3.1	4.1	3.4	7.3	3.9
Maximum wind speed* (m s^{-1})	11.1	10.5	9.8	9.9	6.4	12.4	10.6	14.7	11.1	11.7	12.6	14.8	14.8
Direction of max. wind* (deg.)	120	181	141	155	116	174	168	121	156	142	156	125	125
Average station pressure (hPa)	680.7	678.2	679.3	680.3	680.6	680.6	681.2	681.8	681.0	680.5	681.3	679.5	680.4
Maximum pressure* (hPa)	685.6	681.9	684.3	682.6	682.7	683.0	683.9	684.8	683.5	684.7	684.8	682.7	685.6
Minimum pressure* (hPa)	676.4	672.1	675.0	677.1	677.5	677.7	678.8	679.4	678.4	677.1	675.3	675.4	672.1
Average air temperature (°C)	8.5	5.8	7.0	7.7	8.9	8.9	10.5	10.6	9.8	9.1	9.1	7.6	8.6
Maximum air temperature* (°C)	16.7	12.5	12.7	13.0	15.8	15.6	15.8	15.7	15.8	14.0	16.6	14.0	16.7
Minimum air temperature* (°C)	-0.2	-0.7	-0.8	0.0	1.6	2.4	3.3	3.0	2.5	2.5	1.3	-0.8	-0.8
Average dewpoint temperature (°C)	-11.9	-6.1	-11.5	-5.7	-5.0	-2.9	-4.4	-2.1	-2.7	-3.3	-6.4	-13.0	-6.4
Maximum dewpoint temperature* (°C)	8.1	4.8	4.2	4.4	6.8	7.2	7.6	9.5	8.8	7.4	9.1	6.9	9.5
Minimum dewpoint temperature* (°C)	-37.1	-26.4	-34.7	-29.5	-26.4	-27.7	-24.5	-23.2	-23.9	-25.3	-27.8	-29.5	-37.1
Precipitation (mm)	0	20	1	5	9	25	0	6	13	0	69	44	192

Instrument heights: wind, 10.2 m; pressure, 3398.4 m (MSL); air temperature, 2.0 m; dewpoint temperature, 2.0 m. Wind and temperature instruments are on a tower 15 m southwest of the main building.

*Maximum and minimum values are hourly averages.

TABLE 1.10. SMO 2000 and 2001 Monthly Climate Summary

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							2000						
Prevailing wind direction	---	---	---	ESE	ESE	SE	SSE	SE	SE	ESE	ESE	WNW	SE
Average wind speed (m s^{-1})	---	---	---	4.5	5.2	7.9	6.3	6.6	6.4	6.5	5.2	4.5	5.9
Maximum wind speed* (m s^{-1})	---	---	---	11.3	11.6	15.6	15.1	13.3	13.5	13.9	11.6	11.5	15.6
Direction of max. wind* (deg.)	---	---	---	118	121	128	139	133	127	131	131	297	128
Average station pressure (hPa)	1000.1	1001.8	1001.2	1001.3	1002.2	1002.9	1002.8	1002.5	1003.8	1001.5	1000.6	998.7	1001.6
Maximum pressure* (hPa)	1005.4	1006.5	1005.3	1005.3	1006.0	1006.7	1007.5	1006.2	1007.3	1005.4	1004.9	1003.2	1007.5
Minimum pressure* (hPa)	993.1	996.8	996.1	997.6	997.8	998.1	998.4	998.5	999.8	996.0	995.4	993.5	993.1
Average air temperature (°C)	27.1	27.1	26.9	27.3	26.8	26.6	25.7	25.6	26.2	26.1	26.8	27.3	26.6
Maximum air temperature* (°C)	28.4	28.7	28.7	29.1	29.2	29.1	27.7	27.0	27.7	27.4	28.0	29.6	29.6
Minimum air temperature* (°C)	23.2	23.1	22.8	23.0	22.4	23.3	23.2	22.8	22.8	22.8	23.3	24.5	22.4
Average dewpoint temperature (°C)	22.9	23.0	23.2	23.3	22.7	22.5	21.1	22.4	22.4	22.6	23.3	23.2	22.7
Maximum dewpoint temperature* (°C)	24.3	24.6	24.4	24.5	24.7	24.5	23.7	24.4	23.8	24.1	24.6	25.5	25.5
Minimum dewpoint temperature* (°C)	19.9	20.5	21.5	21.5	17.0	17.8	15.4	19.4	20.5	20.4	18.5	20.6	15.4
Precipitation (mm)	364	189	166	200	172	156	93	33	93	256	168	220	2110
							2001						
Prevailing wind direction	E	E	NW	ESE	SE	ESE	SSE	SE	SE	SE	SE	SE	SE
Average wind speed (m s^{-1})	4.6	4.4	5.1	4.0	6.0	5.8	5.3	8.2	8.7	7.6	7.7	4.9	6.0
Maximum wind speed* (m s^{-1})	11.0	12.8	15.2	11.6	14.0	11.9	12.6	13.5	17.0	16.7	16.0	14.9	17.0
Direction of max. wind* (deg.)	319	92	322	132	152	126	148	142	140	137	127	330	140
Average station pressure (hPa)	1001.1	999.0	1000.1	1000.4	1001.3	1000.8	1002.2	1002.2	1002.9	1001.3	1000.8	996.9	1000.8
Maximum pressure* (hPa)	1004.4	1002.7	1004.2	1003.7	1005.7	1005.1	1005.8	1006.5	1007.3	1005.6	1005.0	1000.8	1007.3
Minimum pressure* (hPa)	997.7	995.0	993.5	997.1	996.7	997.4	996.2	995.8	999.4	996.3	996.8	992.8	992.8
Average air temperature (°C)	27.5	27.2	27.3	27.3	27.0	26.7	26.3	25.9	25.8	26.0	26.6	26.9	26.7
Maximum air temperature* (°C)	28.9	28.7	28.8	29.2	28.9	27.8	28.1	27.4	27.4	27.6	27.8	28.6	29.2
Minimum air temperature* (°C)	23.4	23.3	23.8	23.9	24.7	24.0	22.8	23.7	23.4	22.5	23.9	23.3	22.5
Average dewpoint temperature (°C)	23.1	23.1	23.9	23.8	23.3	24.0	22.6	22.5	22.9	23.2	23.7	23.9	23.3
Maximum dewpoint temperature* (°C)	24.8	24.5	25.2	25.2	25.8	25.5	25.6	25.0	25.1	25.2	25.3	25.7	25.8
Minimum dewpoint temperature* (°C)	21.3	21.4	21.7	20.7	16.6	22.0	15.8	17.5	17.7	19.6	19.2	19.9	15.8
Precipitation (mm)	137	132	---	104	220	226	134	48	141	233	210	451	2036

Instrument heights: wind, 22.9 m; pressure, 78.5 m (MSL); air temperature, 18.9 m; dewpoint temperature, 18.9 m. Wind and temperature instruments are on Lauagae Ridge, 110 m northeast of the main building.

*Maximum and minimum values are hourly averages.

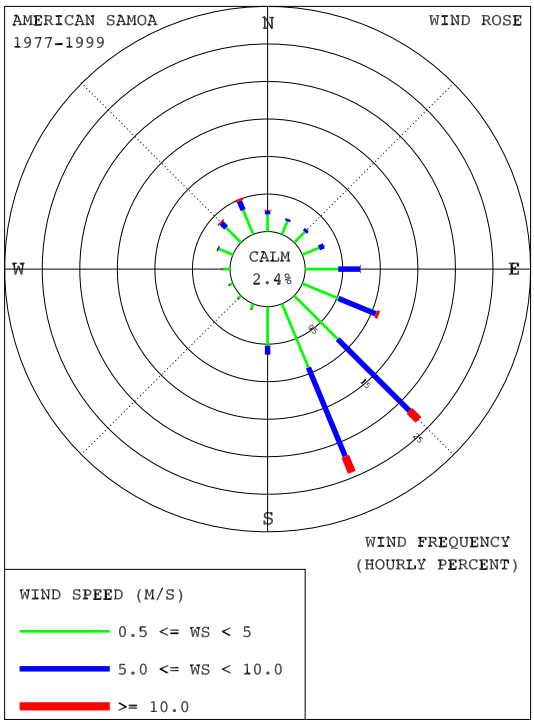


Fig. 1.7. Wind rose of surface winds at SMO for 1977-1999. The distributions of prevailing wind direction and speed are given in units of percent occurrence for the 23-yr period for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graph.

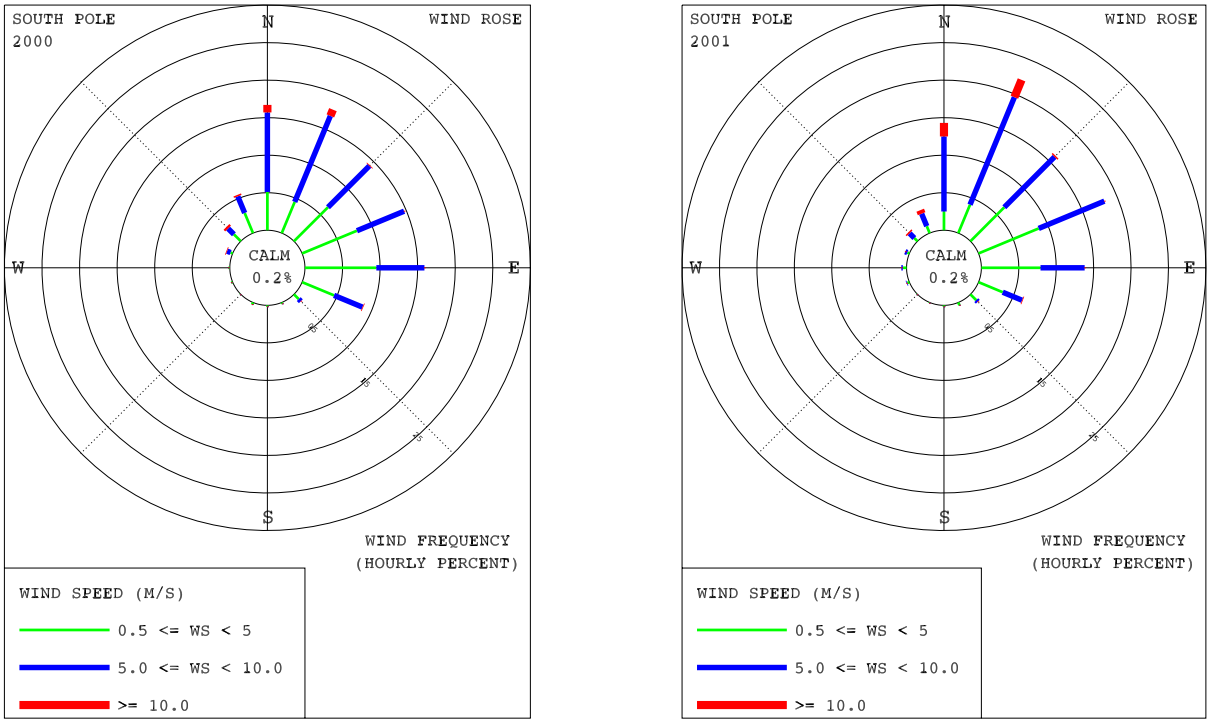


Fig. 1.8. Wind roses of surface winds at SPO for 2000 (left) and 2001 (right). The distributions of prevailing wind direction and speed are given in units of percent occurrence for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graphs.

TABLE 1.11. SPO 2000 and 2001 Monthly Climate Summary

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
							2000						
Prevailing wind direction	NNE	E	E	ENE	E	E	N	NE	NE	N	NNE	NNE	NNE
Average wind speed (m s^{-1})	4.4	4.1	4.7	5.5	5.4	5.8	6.2	5.5	6.0	5.7	6.7	4.1	5.4
Maximum wind speed* (m s^{-1})	10.1	10.3	16.0	11.6	14.3	11.6	12.2	11.0	11.4	12.5	14.9	7.7	16.0
Direction of max. wind* (deg.)	353	354	318	107	15	27	3	347	114	358	289	11	318
Average station pressure (hPa)	681.1	680.6	681.3	679.8	676.3	681.3	677.1	676.9	678.6	672.5	687.4	691.5	680.3
Maximum pressure* (hPa)	690.4	694.2	695.0	692.4	695.7	701.3	697.3	694.4	702.8	682.1	697.8	699.9	702.8
Minimum pressure* (hPa)	672.4	670.7	668.7	666.5	663.2	665.6	664.9	662.7	659.9	660.2	668.7	681.3	659.9
Average air temperature (°C)	-30.2	-42.7	-54.7	-61.4	-59.3	-59.1	-60.1	-59.2	-60.4	-50.4	-33.4	-27.4	-50.1
Maximum air temperature* (°C)	-23.4	-29.1	-35.4	-45.7	-40.1	-41.0	-41.5	-42.8	-41.8	-34.2	-24.0	-24.0	-23.4
Minimum air temperature* (°C)	-38.7	-57.1	-69.7	-71.0	-71.1	-74.7	-74.1	-73.4	-74.8	-63.6	-51.8	-31.1	-74.8
Average dewpoint temperature (°C)	-33.3	-47.1	-58.8	-65.6	-62.9	-63.1	-64.5	-63.3	-64.5	-54.2	-36.9	-30.8	-53.7
Maximum dewpoint temperature* (°C)	-25.5	-32.6	-38.1	-49.7	-43.3	-44.6	-45.3	-46.2	-45.0	-37.5	-27.4	-27.1	-25.5
Minimum dewpoint temperature* (°C)	-42.7	-61.9	-74.3	-75.0	-74.9	-79.4	-78.8	-78.2	-79.6	-68.1	-56.2	-34.8	-79.6
Precipitation (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0
							2001						
Prevailing wind direction	NE	N	NNE	E	NNE	NNE	ENE	NNE	N	ENE	ENE	NNE	NNE
Average wind speed (m s^{-1})	4.0	4.1	6.2	5.8	6.0	6.7	6.3	6.8	6.4	6.2	5.8	5.3	5.8
Maximum wind speed* (m s^{-1})	7.5	8.5	13.2	11.5	14.6	13.4	14.7	12.2	13.3	12.4	12.6	9.5	14.7
Direction of max. wind* (deg.)	23	328	28	11	2	27	16	5	8	23	349	11	16
Average station pressure (hPa)	687.7	688.4	678.7	675.4	680.5	677.6	679.2	669.7	677.5	672.9	681.3	683.2	679.3
Maximum pressure* (hPa)	695.3	696.1	692.4	686.9	697.7	692.3	694.3	689.5	697.8	686.9	690.4	697.5	697.8
Minimum pressure* (hPa)	681.0	676.8	669.6	662.0	667.6	666.5	662.3	654.0	660.8	652.2	671.1	670.8	652.2
Average air temperature (°C)	-29.2	-38.5	-55.7	-59.6	-57.9	-57.3	-60.6	-63.4	-56.4	-53.2	-34.8	-26.3	-49.6
Maximum air temperature* (°C)	-23.3	-25.9	-38.6	-44.7	-40.2	-41.4	-39.8	-40.6	-33.2	-30.4	-22.4	-21.6	-21.6
Minimum air temperature* (°C)	-36.1	-53.4	-64.6	-70.9	-70.8	-69.8	-73.2	-76.0	-72.1	-69.6	-42.7	-34.4	-76.0
Average dewpoint temperature (°C)	-32.7	-42.5	-58.6	-63.8	-62.0	-61.1	-64.6	-67.6	-60.0	-57.3	-39.0	-29.8	-53.6
Maximum dewpoint temperature* (°C)	-26.0	-29.0	-41.8	-48.1	-43.2	-44.6	-43.3	-44.1	-36.4	-33.7	-25.2	-24.7	-24.7
Minimum dewpoint temperature* (°C)	-40.3	-58.1	-69.3	-75.7	-75.7	-75.3	-78.2	-80.7	-76.1	-73.6	-47.2	-38.1	-80.7
Precipitation (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0

Instrument heights: wind, 10.3 m; pressure, 2841 m (MSL); air temperature, 2.0 m; dewpoint temperature, 2.0 m. Wind and temperature instruments are on a tower 91.4 m grid north-northwest of the Atmospheric Research Observatory.

*Maximum and minimum values are hourly averages.

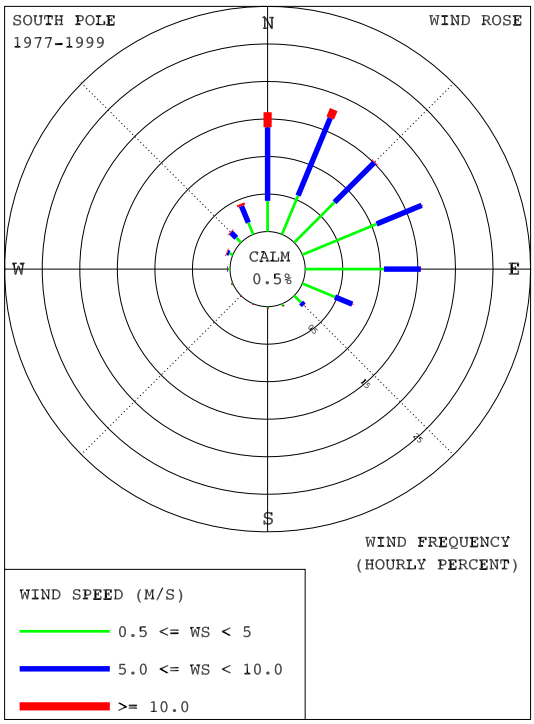


Fig. 1.9. Wind rose of surface winds at SPO for 1977-1999. The distributions of prevailing wind direction and speed are given in units of percent occurrence for the 23-yr period for 16 direction classes and 3 speed classes. Percent frequency of calm winds (WS < 0.5 m s^{-1}) is indicated on the graph.

The average ambient temperatures for 2000 (26.6°C) and 2001 (26.7°C) (Table 1.10) were both cooler than the 23-yr average of 27.0°C. The average barometric pressure for 2000 (1001.6 hPa) was higher than the 23-yr average of 1000.9 hPa, whereas for 2001 (1000.8 hPa) it was slightly below the climatological average. Low-pressure records were tied in both January and February 2000. The precipitation amounts in both 2000 (2110 mm) and 2001 (2036 mm) were higher than the climatological average of 1754 mm.

South Pole

The distributions of the surface wind directions in 2000 and 2001 (Figure 1.8) show percentages of "clean air" sector (grid north-northwest through east-southeast) winds of 93.8% in 2000 and 94.3% in 2001, similar to the 23-yr average of 93.8% (Figure 1.9). The percentage of winds in the 10 m s^{-1} or greater class was 2.7% in 2000 and 5.3% in 2001, compared with 4.0% for the long-term average. The annual average wind speed for 2000 (5.4 m s^{-1}) equaled the climatological average wind speed of 5.4 m s^{-1}, whereas the wind speed for 2001 (5.8 m s^{-1}) was higher than the climatological average.

The average temperatures for 2000 (−50.1°C) and 2001 (−49.6°C) (Table 1.11) were both colder than the long-term average of −49.3°C. January and February 2000 both set new record minimum temperatures for the month. The minimum temperature in 2000 of −74.8°C occurred in September. The minimum temperature in 2001 of −76.0°C occurred in August. The annual average barometric pressure for 2000 (680.3 hPa) was 1.1 hPa higher than the 23-yr average of 679.2 hPa, whereas for 2001 (679.3 hPa) it was slightly above average.